Pak. j. life soc. Sci. (2025), 23(1): 2783-2794 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences

www.pjlss.edu.pk

https://doi.org/10.57239/PJLSS-2025-23.1.00219

RESEARCH ARTICLE

The Creativity Skills of Students in PjBL and CPjBL Model: An Experimental Study

Rusly Hidayah[1,2], I Wayan Dasna[3], Parlan[4], Nazriati[5]

[1,3,4,5] Universitas Negeri Malang

[2] Universitas Negeri Surabaya

ARTICLE INFO

Received: Nov 17, 2024

Accepted: Jan 8, 2025

Keywords

Creativity Skills

Project-

Based

Learning

Collaborativ

e Learning

Collaborative-Project Based Learning

***Corresponding Author:**

rusly.hidayah.2003319@students.um.ac.id

ABSTRACT

The study aimed to compare students' creativity skills using the Project-Based Learning (PjBL) model and the Collaborative Project-Based Learning (CPjBL) model. The study was carried out using a quasi-experimental method. To reveal creative skills, students employed a testing technique. A test was utilized to analyze the data. The study's results indicated a significant difference in students' creativity skills between the Project-Based Learning (PjBL) model and the Collaborative Project-Based Learning (CPjBL) model. These differences are largely influenced by the instructional model's syntax or stages. The findings demonstrate that CPjBL is more effective for enhancing students' creativity skills. In the PjBL model, learning activities focus primarily on the project assignment. In contrast, the CPjBL model begins with motivating students to achieve the learning outcomes, using modules that promote collaborative learning. This approach includes understanding concepts and work principles through instructional media, creating prototypes, engaging in discussions, and demonstrations. Collaborative learning structured group projects around assigned topics. Students would continue project assignments with consistent group members and learning themes. The CPjBL model is superior to the PjBL model because the model's syntax is systematically organized based on a learning hierarchy.

INTRODUCTION

In the future work environment, every activity will face various challenges that must be addressed; therefore, students must master creative skills. Mohamed and Omar (2010) noted that creativity is one of the essential skills required by industry for graduates. According to Kamdi (2011), the most effective educational approach is to create a learning environment that allows students to engage in activities where they can apply their knowledge to solve practical problems and better understand and utilize technology. University education provides students with the opportunity to learn how to tackle these problems.

Smaldino et al. (2012) highlighted that by addressing real-world problems, students can acquire the knowledge and skills necessary for their post-graduate lives. Learning activities that enable students to engage in problem-solving can help them investigate how issues arise and determine effective solutions, thus facilitating the acquisition of new knowledge while reinforcing existing understanding

(Merrill, 2002; Yeen-ju et al., 2015).

Creativity has become an essential skill for graduates in chemistry education, as they will encounter numerous challenges in their careers. Developing these skills enables individuals to express themselve uniquely (Muhlihasari, Susilo, and Ibrohim, 2024). Creative thinking skills enable them to generate new ideas or concepts to overcome difficulties (Cahyo, Susilo, and Sulisetijono, 2021). This article aims to compare the differences in students' creativity skills between two educational approaches: Collaborative Project-Based Learning (CPjBL) and Project-Based Learning (PjBL) in the context of a reaction rate course.

Project-Based learning immerses students in activities focused on completing project tasks derived from real-world scenarios. In contrast, CPjBL combines elements of collaborative learning and project-based learning. Initially, students engage in collaborative learning to study the design of a product through research of academic papers, books, or theses. Following this, they undertake project tasks rooted in real-world contexts.

Project-Based Learning

Project-Based learning is a teaching model that enables students to engage in project assignments while applying learning theories rooted in constructivism. This approach encourages students to address real-world problems or challenges through a thorough process of investigation (Lattimer and Riordan, 2011). It operates under the principle of constructivism, allowing learners to utilize their knowledge and skills to find solutions to practical issues (Arcidiacono et al., 2016). Based on Maulida et al. (2024), in implementing this teaching model, students are encouraged to practice questions in daily life so they are able to create knowledge and form learning projects that are in accordance with the problem topic.

Project-Based learning has significant applicability in chemistry education (Zhang, 2013). Within this model, students have the opportunity to apply their knowledge and skills to tackle structured problems, either individually or in groups (Ng et al., 2016). These project assignments are often inspired by actual industry practices (Jalinus and Nabawi, 2018).

Students who build or design a project must have certain skills, including science process skills, which can be developed through project-based learning (Jusuf, Wijaya, and Dasna, 2021). Through designing and creating projects, students are not only able to acquire science content but are also able to express their creative thinking skills through science knowledge (Sumarni, Wijayanti, Supanti, 2019). The Project-Based learning framework is designed to develop students' attitudes, knowledge, and skills through activities that relate to real-world problems. Project-based learning (PjBL) is designed to be used on complex problems that students need to invest (Sulistina, et al., 2023).

Additionally, Project-Based Learning fosters motivation and enhances students' understanding of real-world applications as the foundation for their project tasks (Balve and Albert, 2015). Because they are actively involved in the investigation, discovery, and decision-making process, students can select the activities and work completed during project activities. They can also be creative, communicative, and develop practical thinking (Rosidah, Susilo, and Mahanal, 2019). This approach also contributes to the development of students' emotional and psychomotor skills (Baran et al., 2018). Furthermore, project-based learning not only aligns with the philosophy of teaching chemistry but also positions students as the central focus of the educational process, allowing them to acquire deeper knowledge and skills (Xinyan, 2016).

Collaborative-Project Based Learning

Numerous studies have been conducted to develop Project-Based Learning in combination with other educational methods. Nepal and Jenkins (2011) discussed the integration of Project-Based Learning with traditional lecture and tutorial-based teaching. Their findings indicated that a well-designed blended approach can effectively address the limitations of both methods.

Mohamed et al. (2011) focused on the implementation of Project Oriented Problem-Based Learning (POPBL). In their study, students were tasked with designing an electronic circuit, which provided them with valuable experience in both individual learning processes and group dynamics, including leadership skills.

Ana and Nurlaela (2012) developed the Patisserie Project-Based Learning (P2BL) model, emphasizing the importance of equipping students with creativity, divergent thinking, and collaborative teamwork skills. Vila et al. (2017) conducted a study on collaborative engineering learning through project-based learning, aimed at developing Industry 4.0 skills using a Product Lifecycle Management (PLM) framework. Their research suggested that project-based learning is a suitable approach for providing experiences that foster the development of competencies needed in Industry 4.0.

In educational settings aimed at enhancing competencies, it is essential for students to engage in interconnected group work. This type of learning, known as collaborative learning, enables students to support each other in improving and developing their skills, as noted by Siegel (2005). Many engineering schools worldwide advocate for cooperative learning in educational activities, as confirmed by Johnson and Johnson (1999), who found it to be effective in higher education. The goal of collaborative learning is to enhance effective learning both within and outside the classroom through group activities, as highlighted by Azizan (2018). Collaborative learning produces more holistic results. In addition, collaborative activities encourage each individual involved to exchange knowledge so that the information obtained is more comprehensive (Zarkasi, Joharmawan, and Yulistiadi, 2024).

The combination of collaborative and project-based learning is particularly suited for chemistry education, as project-based learning encourages students to construct their knowledge by designing tools or machines to solve real-world problems, while collaboration enhances the effectiveness of the learning process. Perez et al. (2009) suggest that in collaborative project-based learning environments, students actively engage with one another, becoming integrated and interconnected as they participate in project tasks that develop their ability to design real machines. So, this collaborative learning experience can help students provide encouragement and information to each other (Fazhari and Yuniawatika, 2024).

Chen (2004) noted that students would achieve better academic outcomes when collaborative project-based learning was applied to assignments involving web page development. Collaborative learning is an ideal learning strategy to practice the ability to apply concepts. This is because collaborative strategies create a student-centered, contextual, integrated, and collaborative learning environment (Sukmawati, 2023). Moreover, Tafakur and Suyanto (2015) found that this approach significantly boosts student motivation, leading to improved learning results.

THEORETICAL FRAMEWORK

The collaborative project-based learning (CPjBL) model is designed to enhance creative thinking and metacognitive skills among students. This study utilizes CPjBL, which consists of several phases: orientation, organization, collaboration, discussion, and evaluation.

In the orientation phase, lecturers introduce students to authentic problems connected to real-life contexts and motivate them to engage in solving these problems. They observe how students manage challenges during this orientation phase and provide relevant videos related to the topic of reaction rates.

During the organizational phase, lecturers facilitate group discussions centered on problem-solving using electronic learning materials (e-MFIs) in a collaborative setting. The collaboration phase encourages students to gather relevant information, seek explanations, and develop solutions to the assigned problems. Lecturers guide students in completing electronic worksheets (E-LKM), assess students' sense of responsibility regarding the E-LKM tasks, and identify the difficulties students encounter while understanding the E-LKM. Students are also encouraged to reach out to resource persons from other departments besides chemistry to help formulate alternative solutions.

In the discussion phase, lecturers prompt students to present their findings from the E-MFI discussions in front of the class. They observe the challenges students face in delivering their discussion results and how these difficulties may impact their presentations. The evaluation phase involves lecturers assisting students in reflecting on their work, comparing their outcomes with the expected results, and considering their satisfaction with these outcomes, as well as the efforts made to improve.

The implementation of CPjBL in this structured manner enables students to tackle complex, challenging, and realistic tasks collaboratively. Although assistance is provided, it primarily serves as reinforcement or scaffolding (Slavin, 2011). Throughout the series of CPjBL activities—from orientation to evaluation—students develop knowledge across different dimensions: factual (orientation phase), conceptual (organizational phase), procedural (collaboration and discussion phases), and metacognitive (evaluation phase). The evaluation phase represents a crucial moment for metacognitive development, as it involves reviewing all activities from start to finish and assessing students' understanding of data/information and their ability to utilize it to solve problems. Thus, CPjBL cultivates greater creativity and metacognitive skills in students, particularly in stimulating and encouraging independent thinking (Moreno, 2010).

In implementing CPjBL, lecturers support students in comprehending laboratory equipment and the media required for investigations, facilitate the formation of study groups, and provide electronic student worksheets (e-LKM). These e-MFIs aid students in following through on problem-solving initiatives, especially during the orientation, collaboration, and discussion phases. Enhanced creative thinking skills enable students to take on their roles and responsibilities more effectively, contributing to the success of scientific investigations and creative tasks. As students develop their creative thinking abilities, they also enhance their capacity to monitor and pay attention to their own thought processes (Hargrove & Nietfeld, 2015).

This suggests that metacognitive skills develop alongside creativity. Furthermore, students' sense of responsibility grows not only due to their metacognitive advancement but also because of the collaborative social environment within their groups (Shamir et al., 2008). This sense of responsibility significantly contributes to the success of scientific investigations and creative tasks assigned to students. In essence, responsibility acts as a moderating variable in the CPjBL learning process.

METHODOLOGY

The study employed a quasi-experimental method using a two-group research design to examine the reaction rate course in the Bachelor of Chemistry Education program at the Chemistry Education Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Indonesia. The research population consisted of 52 students, divided into two groups of 26. The control group utilized the Project-Based Learning (PjBL) model, while the experimental group implemented the Collaborative Project-Based Learning (CPjBL) model.

The primary difference in treatments between the two groups lies in the structure, or syntax, used during the learning process. According to Eggen and Kauchak (2012), syntax refers to the series of steps that help students achieve a learning goal. The syntax for both models is outlined in Table 1.

In the control group, learning activities followed the PjBL model as described by Kamdi (2010), which consists of seven stages. In contrast, the experimental class performed learning activities based on the CPjBL model, which includes ten stages. This CPjBL model has been validated by experts and is considered reliable for implementation in chemistry education.

In the PjBL model, students engage directly in project tasks from the outset. Conversely, the CPjBL model requires students to first acquire knowledge about the teaching materials (through modules, articles, theses, prototype media, and video learning) within a collaborative learning framework, followed by engaging in project tasks during the learning activities. Therefore, the key distinction between the PjBL and CPjBL models lies in the learning stages involved.

Table 1: Comparison of the syntax between Project-Based Learning (PjBL) and Contextual Project-Based Learning (CPjBL) models implemented in the Reaction Rate course.

Control Class		Experiment Class	
Stage	**PjBL**	**Stage**	**CPjBL**
1	Determination of project theme by teacher and students	1	The formulation of the expected learning outcome
2	Division of students group work	2	Understanding the concept of teaching material
3	Observation and identification of various problems	3	Demonstration prototype media and video learning
4	Preparation of project proposal	4	Project assignment (students are assigned to identify problems from the real-world as the basis of the project and relevant to the course)
5	Production process	5	Approval of the student's project plan with experts
6	Assessment of process or product and feedback of students work method	6	Working on the project proposal
7	Presentation of project report	7	Progress check of the project proposal
		8	Analyse, design and create detailed design to produce nata de coco (blueprint) of the project
		9	Progress check of the analysis design and create detailed design to produce nata de coco of the students' project

Assessing students' creativity skills is conducted through tests. Observers evaluate students on a scale from 1 to 5. The instrument used to assess these creativity skills is outlined in Table 2. Students' creativity skills are measured across four aspects: fluency, flexibility, originality, and elaboration.

Fluency refers to the ability to generate a large number of ideas or solutions. Flexibility is the capacity to produce varied ideas, responses, or questions, to view problems from multiple perspectives, and to employ different approaches to problem-solving. Originality is the ability to come up with new and unique ideas. Elaboration involves providing detailed explanations or expansions of ideas (Rolia et al., 2018; Yulianto, 2021).

Table 2: Instrument of the assessment of students' creativity skills

No	Aspect	Score (1-5)
1	Flexibility	
2	Originality	

3	Elaboration	
4	Fluency	

Before conducting a comparative analysis of students' creativity skills, it's essential to perform a requirements test, as well as tests for normality and variance homogeneity. The data analysis in this experimental research utilizes a T-test to compare the creativity skills of students in both the experimental and control groups. This process aims to validate the hypothesis that there is a significant difference in creativity skills between the two groups after receiving treatment through Project-Based Learning (PjBL) and Collaborative Project-Based Learning (CPjBL). A significant difference is indicated when the significance value (2-Tailed) is less than 0.05.

RESULTS AND DISCUSSIONS

Result

Analysis Requirement Test

The normality test is conducted using the Kolmogorov-Smirnov test with a significance level greater than 0.05. The results of the test are presented in Table 3.

Table 3: Normality and Homogeneous test of creativity skill students

No	Creativity skills	PjBL		CPjBL		Levene Statistic	Sig
		Sample K-S	Sig.	Sample K-S	Sig.		
1	Flexibility	0.377	0.514	2.209	1.501	0.148	0.702
2	Originality	0.217	0.300	0.132	1.200	0.475	0.304
3	Elaboration	0.211	0.400	2.217	0.320	1.158	0.287
4	Fluency	0.206	0.06	0.132	0.200	0.541	0.466
Total		0.417	0.07	0.307	0.250	0.219	0.225

The results of the creativity assessment normality test, as shown in Table 3, indicate that the significance (2-tailed) value for the control class is 0.07, while for the experimental class it is 0.307. Since both values are greater than 0.05, we can conclude that the creativity data for both classes are normally distributed.

Furthermore, a homogeneity test was conducted on the creativity assessments using Levene's Statistic. A significance level above 0.05 indicates that the data are homogeneous. According to Table 3, the significance value for the creativity assessment is 0.500, which is higher than 0.05. Thus, we can conclude that the creativity data obtained in this study have similar variances.

Based on the results of the prerequisite tests conducted, we can conclude that the data obtained from this research are suitable for proceeding with the t-test analysis.

Comparison of Students Creativity Skill

The comparison of students' creativity skills between the Project-Based Learning (PjBL) model in the control class and the Collaborative Project-Based Learning (CPjBL) model in the experimental class can be identified and analyzed. The analysis reveals a significant difference in creativity skills between the two classes, with a two-tailed significance (Sig.) value of 0.000.

Evaluating the students' creativity skills across five specific items, there were three areas where significant differences were observed and two areas that showed no significant difference. The three items demonstrating significant differences, with two-tailed Sig. values less than 0.05, are:

1. The ability to formulate the problem.

2. The ability to determine the appropriate strategy or steps to solve a real problem.

3. The ability to solve problems through project assignments.

The two items that did not show significant differences, with two-tailed Sig. values greater than 0.05, are:

1. The ability to identify the elements that need to be understood regarding the real problem.

2. The ability to interpret data related to the real problem.

Based on the results of the T-test conducted, we can conclude that there is a significant difference in students' creativity abilities between the PjBL class and the CPjBL class.

Table 4: Comparisons between implemented PjBL and CPjBL model on the level of creativity skills on the reaction rate course

No.	Creativity skills	PjBL		CPjBL		T-Test	Sig. (2-tailed)
		Mean	SD	Mean	SD		
1	Flexibility	3.259	0.439	3.648	0.406	-0.442	0.196
2	Originality	3.517	0.218	4.731	0.419	-2.150	0.304
3	Elaboration	3.371	0.400	3.576	0.530	-0.518	0.132
4	Fluency	3.391	0.425	4.103	0.515	-2.223	0.310

Disscusion

Differentiation of students' creativity skill on learning activity with the implementation of PjBL model and CPjBL model are not separated from the quality of learning activity that is affected by syntax from both models. In control class with learning activity using implementation of PjBL by syntax implementation of Kamdi (2010), students carry out project assignment directly, while in the syntax of CPjBL model, students are provided competence before carrying out project assignment (see table 1). Differences in student creativity abilities between the results of the implementation of the PjBL and CPjBL models viewed from each aspect of the problem skills that have been assessed are discussed comprehensively in the next paragraph. Concerning the skill to identify elements that must be understood in terms of real-world problems, there is no difference between the implementation of PjBL model and CPjBL model. However, students' average values with the implementation of CPjBL model on this aspect are slightly higher (4.30) than the implementation of PjBL model (4.25). Regarding syntax, both models provide an opportunity for students to observe, identify, and determine one of the problems that are urgent as the basis of their project assignment. It is critical that students understand the problems that exist in the real world, which gives students high motivation to solve these problems. According to Pablos and Pozo (2017), project-based learning develops research basic skills and students' critical thinking skill. There are problems with students' critical thinking skill that exist in the real world of this study. According to Saripudin et al. (2015) regarding the development of project-based learning model with student project theme about environmental management, the result of this study shows students' critical thinking skill can be developed. It can be concluded that students' ability to identify elements that must be understood of the real-world problem relate to critical thinking skill. Kim and Choi (2014) mentioned that to succeed in creativity, students need to develop their critical thinking skills in order to analyze the problems that appear. Concerning the skill to formulate the problem that has been identified, there is a significant difference between both models. Students' average values of this aspect with the implementation of CPjBL is 4.25, which is higher than students that implement PjBL model with value of 3.15. The formulation that is made by students is the ability to ask questions that can solve a problem that has been identified. Students creativity competencies of CPjBL group is stronger in this aspect because students understand and learn project that has been made by previous researchers before carrying out project assignment, and this learning activity is available on syntax the second of CPjBL model (see table1). In this learning stage, students are divided into small groups to discuss the topic as their group assignment, write a summary, present it in front of the class and discuss it. The type of learning is known as collaborative learning. The implementation of CPjBL model makes students creativity skill superior to students who underwent implementation of PjBL model. This result corresponds with the study of Neo (2004), who declared that collaborative learning assists students to join in learning group to manage time and their project, increase communication skill and their team spirit, increase their motivation in learning, and increase their understanding about learning material. Collaborative learning teaches students to believe in teacher and have a greater believe in their ability to think, to look for information from another source, and to learn from other students (Syarifuddin, 2011). It can be taken to mean that to make the formulation of the problem, at first students must understand what will be carried out or what is a project involves so that can they can solve problems that exist in the real world. To have this competence, students must understand and learn projects that have been conducted by previous researchers. Learning activities by implementing collaborative learning including module also affected students' abilities to determine the right strategy for solving the real-world problem. There is a significant difference between the implementation of PjBL and CPjBL model of learning. The average score of students' creativity skills with CPjBL model treatment is 4.10, which is higher than students who were treated by PjBL model with an average score of 3.30. Students understood what was the right strategy or stages in solving the problem of learning activity with collaborative learning method that has been applied. Chen and Chuang (2011) argued that collaborative learning assist students to develop their creativity ability because they were able to share ideas, and get to know each other. This can strengthen collaborative learning to support student learning achievement. Concerning the skill aspect of data interpretation of the real problem, there is no significant difference between a class with implementation of PjBL model and class with implementation of CPjBL model. Average scores of students' ability in giving data interpretation of real problem in experiment class was 3.85 and class control was 3.70. The skill of data interpretation of the real problem is students' ability to find the meaning in the real problem.

The fifth aspect of students' creativity skill is the skill of solving the problem with project assignment. In this aspect, there is a significant difference between the implementation of PjBL and the CPjBL model. Average scores for implementation of PjBL model is 3.80, while the average score of CPjBL group is 4.40, which is higher than PJBL group. This can be taken to mean that the combination of collaborative learning and project-based learning has a great influence on the students' skill in solving a problem. The combination of both methods organizes students to learn the process by putting theory into practice, applying concept into the real problem of the project. Collaborative project-based learning is learning that integrates project-based learning that is carried out with collaborative learning strategy (Lazinica and Calafate, 2009). The study of Baser et al. (2017) recommended that implementation of collaborative project-based learning improved student's motivation to design project and to benefit them in real life. The CPjBL model is a combination of two models of learning, which are collaborative learning and project-based learning. First, students learn to understand the theories through learning with collaborative learning. Then, students carry out project tasks with the application of project-based learning model. The treatment of collaborative learning model at the beginning of the process of learning has a great influence on the students' ability to carry out the project assignment. Students feel confident in their ability to solve various problems that appear in designing, choosing, drawing and calculating their project assignment in a group or individually. Meanwhile, students carry out their project directly in implementation PjBL model, and tend to be uncertain, doubtful, perhaps spend too much time on reading and searching for more information, in discussion in the group as well as consulting with a supervisor. When they encounter problems, they have to make a solution and need assistance by discussion and consultation with lecturer. In this case, when lecturers or teachers assist them, most of the way out is created by a teacher or lecturer. Thus, CPjBL is more effective than PjBL in the case of teaching the course of reaction rate.

The results and discussions of an article must be presented in a clear and organized manner, based on the data collected and the analyzes carried out during the study. Initially, the results must be presented in an objective and concise way, using tables, graphs and statistics, if applicable, to highlight the main findings. Then, in the discussion section, the results are interpreted in light of existing literature, highlighting similarities, differences and implications for theory and practice.

Furthermore, limitations of the study and possible directions for future research are discussed. It is essential that both the results and the discussion are based on solid evidence and that they contribute significantly to the advancement of knowledge on the topic addressed.

CONCLUSION

Based on the result of a study that has been carried out about the comparison of students' creativity skill between the implementation of PjBL and CPjBL model, it can be concluded students' creativity skill with the implementation of CPjBL is superior to PjBL model learning activity. CPjBL is thus superior to PjBL in problem creativity skill, as it can organize systematic learning stage of syntax model. Before students carry out project assignment, they learn about the subject matter first through module, book, papers based on cooperative learning, so that they can solve a problem that they face easily when carrying out project assignment. There was debriefing competencies that can help students in solving problems they find when carrying out their project tasks. Combination of collaborative and project-based learning be an effective instructional model to enhance student competence.

REFERENCE

Ana & Nurlela, L. (2012). Development model of Patisserie Project-based Learning. *Journal of Technical Education and Training*, 4 (2), 30–44.

Arcidiacono, G. et al. (2016). Application of axiomatic design for project based learning methodology. *Procedia CIRP*, 53, 166–172. doi: 10.1016/j.procir.2016.08.003

Azizan, M. T., Mellon, N., Ramli, R.M. & Yusup, S. (2017). Improving teamwork skills and enhancing deep learning via development of board game using cooperative learning method in reaction engineering course. *Education for Chemical Engineers,* (22), 1-13. doi: 10.1016/j.ece.2017.10.002

Balve, P. & Albert, M. (2015). Project-based learning in production engineering at the Heilbronn learning factory. Proceeding of the 5th Conference on Learning Factories 2015, Procedia CIRP, 32 (2015), 104-108. doi:10.1016/j.procir.2015.02.215

Baran, M., Maskan, A. &Yasar, S. (2018). Learning Physics Project-based Learning Game Techniques. *International Journal of Instruction,* 11(2), 221-234. doi: 10.12973/iji.2018.11215a

Baser, et al. (2017). Collaborative project-based learning: an integrative science and technological education project. *Research in Science & Technological Education*, DOI: 10.1080/02635143.2016.1274723

Cahyo, F.T.F., Suliso, H., Sulisetijono. (2021). The Relationship Between Critical Thinking Skills And Creative Thinking Skills Of Biology Of High School Students In Think Pair Share (TPS) Learning Model. *Jurnal Pendidikan Sains,* 9(1), 23-26.

Chen, L-L., (2004). Cooperative project-based learning and students' learning styles on web pages development. *J. Educational Technology Systems,* 32 (4), 363 – 375. doi: 10.2190/LRXX-9AE5- F0YA-E92G

Chen, W., and Chuang, C. (2011). Effect of varied types of collaborative learning strategies on young children: An Experimental Study. *International Journal of Instructional Media*, 38 (4), 351 – 358.

Eggen, P. & Kauchack, D. 2012. *Strategi dan Model Pembelajaran: Mengajar Konten dan Keterampilan berifikir.* Edition 6th translate to Indonesian Language. Jakarta: PT. Indeks.

Fazhari, B. A., & Yuniawatika, Y. (2024). Keterampilan Kolaborasi Peserta Didik Kelas V SD dalam Kegiatan Diskusi Kelompok. *Journal of Innovation and Teacher Professionalism*, 3(2), 317– 324.

Jalinus, N., & Nabawi, R., A. (2018). The Instructional Media Development of Welding Practice Course Based on PjBL Model: Enhancing Student Engagement and Student Competences. *Int. J. Innovation and Learning*, 24 (4), 383- 397. doi: 10.1504/IJIL.2018.095365

Johnson, D.W. & Johnson, R.T. (1999). Making cooperative learning work. *Theory Pract*, 38 (2), 67– 73.

Jusuf, N., Wijaya, A., R., Dasna, I.W. (2021). The Effect Of Project Based Learning (PjBL) Learning Model On Students' Science Process Skills On Colloidal Topic. *Jurnal Pendidikan Sains,* 9(3), 100-103.

Kamdi, W. (2010). Implementasi *Project Based Learning* di Sekolah Menegah Kejuruan. *Jurnal Pendidikan dan Pembelajaran,* 17 (1), 98 – 112.

Kamdi, W. (2011). Paradigma baru pendidikan teknologi dan kejuruan: kerangka pikir inovasi pembelajaran. *Teknologi dan Kejuruan,* 34 (1), 81-90.

Kim, K-S & Choi, J-H. (2014). The relation between problem solving ability, professional self-concept, and critical thinking disposition of nursing students. *International Journal of Bio-Science and Bi0-Technology*, 6 (5), 131 – 142. doi: 10.12811/kshsm.2013.7.4.105

Lattimer, H & Riordan, R. (2011). Project Based Learning Engages Students in Meaningful Work. *Middle School Journal*, 43 (2), 18-23. doi: 10.1080/00940771.2011.11461797

Lazinica, A & Calafate, C. (2009). *Technology Education and Development*. Vukovar: InTeh

Maulida, A.P.N., Khotimah, K., Pradhana, K.W.A., Maulidiya, M., Annisa, N.N, Triwahyuni, R.Y., Siguyanto. (2024). Implementasi Model Project Based Learning (PjBL) di SMP Negeri 3 Malang. *Jurnal Pembelajaran, Bimbingan, dan Pengelola Pendidikan, 4(2), 4.*

Merrill, M., D., (2002). First principles of instruction. *Educational Technology Research and Development*, 50 (3), 43- 59.

Mohamed, et al. (2011). An Implementation of POPBL for analog electronics (BEL10203) course at the faculty of electrical and electronic engineering, UTHM. *Journal of Technical Education and Training*, 3 (2), 45–53.

Mohamed, W., A., W., & Omar, B. (2010). Development problem solving skills for lifelong learning through workbased learning among community college student. *Journal of Technical Education and Training*, 2 (1), 1- 8.

Muslihasari, A., Susilo, H., & Ibrohim, I. (2024). The Creative Thinking Skills Profile of Primary Education's Perspective Teacher. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, 33(1), 82–89.

Neo, M. (2004). Cooperative learning on the web: a group based, student centred learning experience in the Malaysian classroom. *Australasian Journal of Educational Technology*, 20 (2), 171 – 190. doi: https://doi.org/10.14742/ajet.1358

Nepal, K., P., &Jenkins. G., A. (2011). Blending project-based learning and traditional lecture-tutorial- based teaching approaches in engineering design course. *Proceedings of the 2011 AAEE conference,* Fremantle, Westren Australia. 338 – 343. Retrieved on December 2017 https://research-repository.griffith.edu.au/handle/10072/46601

Ng, K.K., Wang, F. L, Luk, L. & Kwan, R. (2016). Leveraging education of information technology in business: the application of a project-based, problem-based, and flexible learning model. *Int.*
J. Innovation and Learning, 19 (4), 377–396. doi: 10.1504/IJIL.2016.076796

Pablos, V., B., G. &Pozo, M., M., d. (2017). Project-based learning (PBL) through the incorporation of digital

technologies: An evaluation based on the experience of serving teachers. *Computer in Human Behaviour,* 68, 501 – 512. doi: 10.1016/j.chb.2016.11.056

Perez, E., Pearrocha, I., Perez, A., Serrano, J., Belenguer, E., &Sanchis, R. (2009). Cooperative project- based learning for machine design in the Industrial Engineering Program: Methodologies and experiences. In A. Lazinica and C. Calafate (Eds.), *Technology, Education and Development* (pp. 395 – 414). Vukovar: In-Teh. Doi: 10.5772/7273

Rosidah, N.U., Susilo, H., Mahanal, S. (2019). mproving Creative Thinking Skills of Students ThroughLearning Based on Simple Hydroponic Projects. *Jurnal Pendidikan Sains*, 7(3), 111- 115.

Saripudin, A., Haryani, S., &Wardani, S. (2015). Characterized project based learning to improve critical thingking skill. ICMSE 2015 *Proceedings* (pp. 6 – 11). Retrieved on December 2017 at http://icmseunnes.com/2015/wpcontent/uploads/2016/03/46_CE.pdf

Siegel, C. (2005). Implementing a research based model of cooperative learning. *The Journal of Educational Research,* 98 (6), 339-349.

Smaldino, S., E., et al. (2012). *Teknologi Pembelajaran dan Media Untuk Pembelajaran*. Translate to Indonesian language by Arif Rahmat. 2011. Jakarta: Kencana.

Sukmawati, F. 2023. Project-Based Collaborative Learning On Student Concept-Application With Different Prior Knowledge. *JKTP: Jurnal Kajian Teknologi Pendidikan,* 6(4), 230-240*.*

Sulistina, O., Widarti, H.R., Habiddin, Herunata, Yahmin, Hasanah, S.M.H., Zahirah, D.F. (2023). Training of Development of Inquiry-Based and Project-Based Chemistry Learning Design for Chemistry &Science Teachers. *J-PEK (Jurnal Pembelajaran Kimia)*, 8(1), 43-35.

Sumarni, W., Wijayanti, N., Supanti, S. 2019. Kemampuan Kognitif Dan Berpikir Kreatif Siswa Melalui Pembelajaran Berbasis Proyek Berpendekatan STEM. *Jurnal Pembelajaran Kimia,* 4(1), 18- 30.

Syarifuddin, A. (2011). Model Pembelajaran Cooperative Learning Tipe Jigsaw Dalam Pembelajaran. *Ta'dib,* 16 (2), 209 – 226.

Tafakur & Suyanto, W. (2015) Pengaruh Cooperative project-based learning terhadap motivasi dan hasil belajar praktik "Perbaikan Motor Otomotif' di SMK 1 Seyegan. *Jurnal Pendidikan Vokasi,* 5 (1), 117- 131.

Vila, C., et al (2017). Project-based collaborative engineering learning to develop industry 4.0 skills within a PLM framework. Manufacturing Engineering Society International Conference 2017, MESIC 2017, 28-30 June 2017, Vigo (Pontevendra), Spain. *Procedia Manufacturing* 13 (2017).
Elsevier Ltd, 1269 – 1276. doi:10.1016/j.promfg.2017.09.050

Yeen-Ju, H., T., Mai, N. & Selvaretnam, B. (2015). Enhancing roblem-solving skills in an authentic blended learning environment: A Malaysian Context. *International Journal of Information and Educational Technology*, 5 (11), 841-846. doi: 10.7763/IJIET.2015.V5.623

Zarkasi, N.A., Joharmawan, R., Yulistiadi, G. 2024. Implementasi Project Based Learning Pembuatan Es Putar untuk Mengembangkan Kemampuan Kolaborasi Peserta Didik Kelas 7.4 SMPN 20 Malang. *Jurnal Integrasi dan Harmoni Ilmu-Ilmu Sosial, 4(6).*